

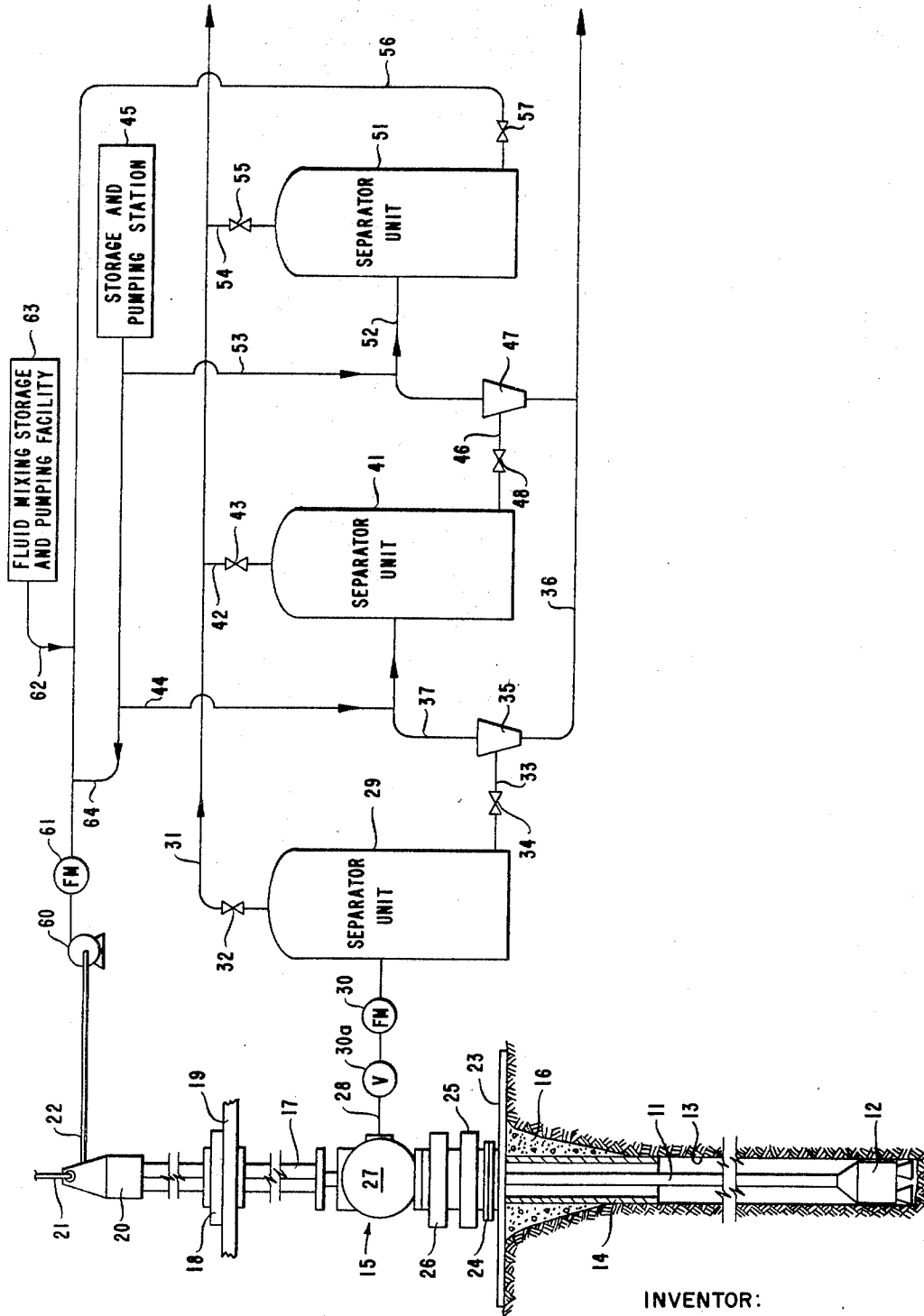
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PRESSURIZED WELL DRILLING SYSTEM

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1

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PRESSURIZED WELL DRILLING SYSTEM

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10 Claims

ABSTRACT OF THE DISCLOSURE

A system for drilling a well wherein a low viscosity drilling fluid is continuously circulated under pressure with the bottom hole pressure thereof being greater than the formation fluid pressure in the formations encountered during the drilling activity.

The present invention relates to an improved system for drilling a well and, more particularly, pertains to an improved method and apparatus wherein the drilling fluid utilized during the drilling operation is of relatively low viscosity and is maintained under continuous pressure during such operation.

In conventional rotary drilling techniques, drilling fluid or "mud" is continuously circulated down through a hollow drilling string, through a bit associated with the string, and thence back up to the surface through the annular space formed between the drilling string and the borehole wall. The drilling fluid, among other functions, flushes the cuttings out of the hole, making removal of tools to clean the hole unnecessary and, by the weight of the column formed thereby, holds in check fluids under pressure in formations penetrated by the bit, thus greatly reducing the risk of blowout.

Accumulated information shows that the greatest drilling rates are usually attained with low viscosity, low density drilling fluids. Clear fluids, such as air, allow the fastest drilling rates, while progressively lower drilling rates result with respect to use of clear water, water carrying suspended matter, light muds (which are relatively free of suspended solids), and heavy muds having a relatively high concentration of suspended solids. When using relatively low density, low viscosity drilling fluids, however, maintenance of bore hole integrity becomes difficult since the pressure exerted by the column of the fluid may be insufficient to overcome the formation pressures encountered during the drilling operations.

SUMMARY OF THE INVENTION

It is therefore a primary object of the present invention to provide a closed system wherein relatively low viscosity, low density fluids may be utilized during well drilling operations.

This and other objects have been attained in the present invention by providing a method and apparatus whereby a low viscosity, low density drilling fluid is forced through a drill string and bit into a well and thence upwardly within the annular space between the string and borehole to remove drill cuttings from the well. The drilling fluid is then suitably treated to remove therefrom drilled solids and any gases entrained therein. Additions are made to the drilling fluid as necessary to replace any lost fluid and to change or maintain the quality and/or quantity thereof as desired. The drilling fluid is then once again introduced down through the drill string. Throughout the entire above-described operation the drilling fluid is maintained under pressure with the down hole pressure thereof being sufficient to overcome formation fluid pressures which may be found in formations encountered by the drill string in its downward course of movement.

2

DESCRIPTION OF THE DRAWING

Other objects, purposes and characteristic features of the present invention will be obvious from the accompanying drawing and from the following description of the invention. In describing the invention in detail, reference will be made to the accompanying drawing in which:

FIGURE 1 is a general view illustrating in schematic fashion the system according to the present invention.

Referring now to FIGURE 1, a conventional drill string 11 having a drill bit 12 affixed thereto in the usual manner is shown as being positioned within borehole 13. The drill string extends upwardly through the through-bore defined by surface casing 14 and into a drilling assembly indicated generally at 15. Surface casing 14 has been secured previously within the borehole by any suitable means such as cement 16. After passing through drilling assembly 15, drill string 11 is connected at its uppermost end to a kelly 17 which rises through a rotary table 18 movably mounted in any suitable manner on drilling frame or work deck 19. The top of the kelly is secured to a swivel 20 which has a bail 21, the bail and top part of the swivel being rotatable with respect to the kelly. The swivel has an inlet pipe 22 which is in communication with the interior of the drill string 11 in the usual manner. The swivel may be of any suitable design. For example, a Brewster SX series oil bath swivel, as described on page 832, volume 1, Composite Catalog of Oil Field Equipment and Services, 1962-1963 edition, may be used.

Drilling assembly 15 includes a base member 23 defining a hole (not shown) through which surface casing 14 passes into locking engagement with a well casing head unit 24 which is secured to base member 23. Connected coaxially above well casing head unit 24 are a series of blowout preventers such as ram-type blowout preventers 25 and 26 and annular blowout preventer 27. The top-most blowout preventer, i.e., blowout preventer 27, has existing therefrom an outlet pipe 28, the purpose of which will be described in greater detail hereafter. It should of course be understood that any commercially available blowout preventers may be incorporated in drilling assembly 15. Likewise, the number of preventers will depend on the actual conditions encountered during drilling activities. Such blowout preventers must, however, be of sufficient size and capacity to withstand the pressures utilized in the system according to the present invention as well as the formation pressures within the well. Since the blowout preventers themselves do not form an essential part of the present invention and are well known in the art, they will not be further described here.

Outlet pipe 28 proceeds from blowout preventer 27 to a separator unit 29 of any suitable known construction. Preferably, a flow meter and rate controller device 30 and valve 30a are provided at desired locations along the length of outlet pipe 28 to provide means for regulating flow through pipe 28. If desired, device 30 may incorporate an alarm to alert the drilling crew with regard to any unbalanced condition in the system detectable at that location such, for example, as lost circulation or impending blowout. Separator unit 29, as stated above, may be of any suitable design and is used to remove produced gas from the drilling fluid. The gas is vented from separator unit 29 through gas discharge line 31 to a suitable location for flaring of the gas. A valve 32 may be disposed in gas discharge line 31 to enable the operator to interrupt the flow of gas from separator unit 29. A drain pipe 33 having a valve 34 disposed therein exits from the lower portion of separator unit 29. Pipe 33 is used to drain the mixture of drilling fluid and drill cuttings from separator unit 29 after the production gas has been substantially removed therefrom. Pipe 33 is connected at its other end to a high pressure cyclone or centrifuge 35

of any suitable design. After the drilling fluid-drill cutting mixture passes through pipe 33 into centrifuge 35, the centrifuge acts to substantially separate the cuttings from the fluid in the well-known manner with the cuttings exiting from the centrifuge through conduit 36 and the drilling fluid sans cutting exiting from the centrifuge through pipe means 37.

Pipe means 37 leads to a second separator unit 41 similar in design to separator unit 29. The effluent exiting from centrifuge 35 passes through pipe 37 into unit 41 whereupon it is subjected to further treatment to additionally substantially remove any production gases still remaining therein after treatment in separator unit 29. Gas from separator 41 exits into a connector pipe 42 leading to gas discharge line 31. A valve 43 may be disposed in connector pipe 42 to enable the operator to interrupt the flow of gas from separator unit 41. Branching into pipe 37 is a feeder conduit 44 which extends from storage and pumping facility or station 45. From station 45 water, brine and premixed mud chemicals are introduced into the closed system for drilling fluid maintenance purposes. Materials flowing from station 45 are introduced into separator unit 41 through pipe 37 along with the effluent from centrifuge 35.

A drain pipe 46 is operatively associated with separator unit 41 to drain the material therefrom after the gas separation function has taken place. Effluent passing from separator unit 41 through drain pipe 46 will comprise the material discharged from centrifuge 35 through pipe 37 plus materials introduced into the system from station 45 less the gas vented from separator 41 through connector pipe 42. Since this effluent may include some drill cuttings not removed by the operation of centrifuge or cyclone 35 drain pipe 46 is connected to a second cyclone or centrifuge 47. A valve member 48 may be disposed in operative association with drain pipe 46 if desired to cut off the flow of material therein. As is centrifuge 35, centrifuge 47 is operatively connected to conduit 36 so that the cuttings from both centrifuges will flow through the conduit to a suitable disposal area such as a conventional collection pit (not shown).

The number of separator units and/or cyclone or centrifuge units employed in the system according to the present invention will of course depend on a variety of factors such as efficiency of the units, capacity of the equipment and drilling fluid and cutting characteristics, for example. In the system illustrated, a third separator unit 51 is employed to receive the effluent discharged from centrifuge 47 through pipe 52 to further treat said effluent to remove any further entrained production gases. It should be noted that a second feeder conduit 53 is connected between pipe 52 and storage and pumping station 45. In this manner, an additional path is provided to introduce water, brine and premixed mud chemicals into the closed system. Production gases removed by separator unit 51 are vented therefrom through connector pipe 54 into gas discharge line 31. A valve member 55 is preferably disposed in connector pipe 54.

After separator unit 51 has performed its gas removing function, the treated drilling fluid is drained therefrom through drain pipe 56, said drain pipe preferably having a valve 57 operably associated therewith. Drain pipe 56 leads to the inlet of a high-pressure pump 60. Preferably, a flow meter and rate controller device 61 is disposed along the length of drain pipe 56 to provide a means for regulating fluid flow therethrough. An alarm may be incorporated in device 61 to alert the drilling crew with regard to any unbalanced condition in the system detectable at that location. A connector conduit 62 is in fluid flow communication with drain pipe 56 at a predetermined location along the length thereof. At its other end, conduit 62 is connected to a conventional drilling fluid mixing, storage and pumping facility 63. In this manner, drilling fluid may be continually replenished to maintain the desired amount of fluid in the system. It should be

noted also that a pipe line 64 leads from station 45 to pipe 56 so that water, brine and premixed mud chemicals may be introduced into the system at still another alternative location for drilling fluid maintenance purposes.

The operation of the subject system will now be described with respect to drilling operations. It will be assumed that a drilling fluid having the desired characteristics, i.e., a low density, low viscosity fluid, has been introduced into the system from station or facility 63. One suitable drilling fluid having these characteristics is that disclosed in copending U.S. patent application Ser. No. 601,555, filed Dec. 14, 1966. In that application is disclosed a low density, low viscosity drilling fluid composition constituting a drilling emulsion including a water phase and an oil phase. The present system, however, may be used with any relatively low density drilling fluid having a low viscosity, preferably in the order of 10 centipoises. Since the precise nature of such fluid forms no part of the present invention and reference may be had to the above referred to application for one example thereof, it is not deemed necessary to describe with greater particularity the type of drilling fluid that may be used to advantage in the present system.

After introducing the desired drilling fluid into the system, pump 60 forces the fluid under a predetermined high pressure, say 2,000-6,000 p.s.i. or more through inlet pipe 22 into the interior of the drill string 11. The pressurized fluid flows downwardly through the string, out bit 12 and upwardly into the annular space formed between string 11 and the cylindrical wall defining borehole 13, thereby removing bit cuttings from the bottom of the borehole. In addition, the subject closed system serves to maintain the bottom hole pressure of the drilling fluid at a magnitude sufficient to overbalance the formation fluid pressure in the formations encountered by the borehole. This is done by pressurizing the fluid in the annular space between the drill string and borehole wall by at least more than the difference between the hydrostatic pressure of the fluid and said formation fluid pressure. Such formation fluid pressures are subject to continued change during the drilling operation and the downhole pressures are preferably continually monitored so that appropriate adjustments may be made both with respect to the drilling fluid pressure and the quality or makeup of the fluid itself. If desired, a check valve (not shown) may be positioned in the drill string to prevent back flow of drilling and/or formation fluids through the drill string due to pressure changes.

The drilling fluid, drill cuttings, as well as any entrained gas or formation fluids picked up thereby are forced upwardly with the borehole and exit through outlet pipe 28 whereupon the effluent passes flow meter and rate controller device 30 into the above-described arrangement of separator units and centrifuges, serving to remove the drill cuttings and entrained gases therefrom. The thus treated drilling fluid passes through drain pipe 56 back into the pump 60. Additions may be made to the drilling fluid from stations 45 and 63 as previously described. The drilling fluid, quite naturally, will have lost some pressure during its course through the system and pump 60 will again raise such pressure to the desired predetermined level for further circulation into the well.

When it is necessary to remove the drill string and bit from the well for maintenance or other purposes, the bottom hole pressure may be maintained at a magnitude greater than the formation fluid pressure by displacing the relatively low viscosity drilling fluid from the borehole with sufficient mud of sufficient density to overbalance the formation fluid pressure before removing the string and bit from the borehole.

Although only one specific embodiment of the present invention is disclosed herein, it should be understood that the particular form disclosed has been selected to facilitate explanation of the invention rather than to limit the number of forms which it may assume. For example,

5

a greater or lesser number of separator units and centrifuges than disclosed may be utilized depending on the capacity of the equipment and conditions encountered during the drilling operation. Further, it should be understood that various modifications, alterations, and adaptations may be applied to the specific form described to meet the requirements of practice without in any manner departing from the spirit or scope of the present invention.

I claim as my invention:

1. A method of extending the depth of a borehole in the earth by drilling, said method comprising the steps of: establishing a closed system for the circulation of drilling fluid to and from said borehole;

rotating a drill bit in engagement with the bottom of said borehole at the end of a drill string having a down-flow passage therein so that cuttings are formed by said bit at said borehole bottom;

pressurizing a low viscosity drilling fluid to a predetermined pressure in said closed system;

introducing said pressurized low viscosity drilling fluid from said closed system into said drill string down-flow passage;

providing a fluid-tight seal between said drill string and the borehole wall near the surface of the earth;

forcing said pressurized low viscosity drilling fluid down said drill string so that the fluid exits from said drilling bit and flows upwardly within said sealed annular space externally of said drill string and in contact with said borehole wall to remove said bit cuttings;

maintaining said predetermined pressure at a sufficient magnitude whereby the bottom hole pressure of said drilling fluid is greater than formation fluid pressures encountered during drilling; and

circulating the drilling fluid within said closed system while continuously maintaining the fluid under a pressure greater than atmospheric pressure.

2. The method according to claim 1 wherein said drilling fluid has a viscosity of less than 10 centipoises.

3. The method according to claim 1 including the additional steps of removing said drilling fluid from said borehole and separating entrained solids and gases therefrom while said drilling fluid is in said closed system.

4. The method according to claim 3 wherein said drilling fluid is recirculated into said drill string after said entrained solids and gases are separated therefrom.

5. The method according to claim 1 wherein the bottom hole pressure of said drilling fluid is greater than the hydrostatic pressure of the fluid.

6. The method according to claim 4 wherein additions of selected materials are made to the drilling fluid within the closed system prior to its recirculating into the drill string to maintain said drilling fluid at a desired quantity and quality.

7. Apparatus for extending the depth of a borehole in the earth by drilling, said apparatus comprising:

6

a drill string having passage means and extending into said borehole and carrying a rotary drill bit at the lower end thereof, said bit adapted to contact the bottom of said borehole to form cuttings and said drill string and wall of said borehole defining an annular space therebetween;

means forming a fluid-tight seal between said drill string and the borehole wall near the surface of the earth;

pump means having inlet means and outlet means, said outlet means being in communication with the passage means of said drill string whereby drilling fluid will be pumped under a pressure of predetermined magnitude into said passage means, outwardly of said drill string near the bottom of said borehole, and upwardly into said sealed annular space defined by said drill string and borehole wall while contacting said wall; and

means communicating with said annular space and defining a fluid flow passageway for said drilling fluid and entrained bit cuttings externally of said borehole, said passageway leading to the inlet of said pump means;

said pump means, said drilling string, said sealed annular space and said passageway comprising a closed system whereby said drilling fluid may be continuously maintained under a pressure greater than atmospheric pressure.

8. The apparatus according to claim 7 wherein said means communicating with said annular space and defining a fluid flow passageway includes separator means for removing entrained gas from said drilling fluid.

9. The apparatus according to claim 8 wherein said means communicating with said annular space and defining a fluid flow passageway further includes means for adding materials to the drilling fluid whereby the quantity and quality of said fluid are maintained at desired levels.

10. The apparatus according to claim 8 wherein said means communicating with said annular space and defining a fluid flow passageway further includes means for removing drill cuttings from the drilling fluid.

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